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MOTION STUDY FOR THE SUPERVISOR

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BY

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MOTION STUDY FOR THE SUPERVISOR

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PREFACE

It has long been evident that the major weakness of most motion-economy programs has been the enormous amount of detail involved in making original studies and in carrying these studies through to a proposed improved method. Because of the detail involved, most programs have become essentially a staff proposition, handled almost entirely by staff men and affecting the production supervisor only as the program affected the work in his immediate charge. Although the average supervisor has been exposed to motion study in some form or another, the subject usually has been so involved in detail as to make him doubt its practical value. Consequently, he does not fully accept motion study as a trustworthy tool of management and is inclined to be somewhat skeptical of the real value to be derived from its use.

This skepticism is not caused by lack of education in motion study, but the subject material heretofore has not been expressed simply and in

the foreman's language, and it soon lost him in a maze of detail. Once fully understood by the supervisor, motion study should no longer be viewed with suspicion and accepted grudgingly on the basis of material results alone. It should become a welcome aid to the supervisor in the management of his department.

Our purpose, therefore, is to explain the basic principles of motion economy as simply and as logically as possible, including a method of observation that will enable us to study an operation almost as easily as if we were making a time study. Having by means of this method of study, coupled with correct use of the principles of motion economy, duly emphasized the wasted effort in an operation, we can proceed toward the elimination of this waste by means of the cooperative efforts of the comprehending departmental supervisor and the motion analyst.

We cannot and do not expect the supervisor actually to make the motion-study observations in his department, but once he comprehends, through a sound understanding of motion-study principles, what constitutes good or bad practice, he usually becomes the most competent

judge of the value of applying motion study to his operations. As he often knows all the fine points in handling his materials or in performing some intricate operation, he can frequently be counted upon for the nucleus of an idea on how to overcome various problems connected with these operations. To our mind, there is no team surer to pay dividends than a motion-minded supervisor cooperating with a competent motion-study analyst.

NORMAN R. BAILEY.

ROCHESTER, N. Y.,
October, 1942.

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I

THE WHY OF MOTION STUDY

WHENEVER a manufacturer is in a field where the competition is virtually nonexistent, his primary concern, if we consider only the productive end of his business, is to get out the goods so that they may be shipped and the sales price collected. At this stage the only manufacturing to a price is that required to keep the retail value beneath the top limit of the customer's pocketbook. Later on, when others enter into direct competition, it becomes necessary for him to put out a product as good as or better than any of his competitors' and still to remain in the average price range. Finally, when the competition has become intense, the concern that can offer the best article at the lowest selling price, owing to its lower cost of manufacturing, usually becomes the one that dominates the field.

Investigating causes of lowered costs of manufacture may lead us into any one of the three

major items of manufacturing cost: the cost of material, the cost of labor or the cost of burden, or overhead. Since the cost of material is out of our particular field (with the exception of the control of waste) and since a large proportion of the overhead also is out of our immediate control, we shall confine our discussion to the cost of labor.

There are several methods by which a reduction in the cost of labor can be brought about, such as:

1. Wage-incentive plans.
2. Effective planning and layout.
3. Improved methods.

Each of the items listed above might be considered a separate and distinct subject, although in good practice it is exceedingly difficult to consider one without including the others. However, even though these subjects are so closely related, we have no intention of discussing wage-incentive plans here, as this subject has been fully covered by many others. We are more interested in effective planning and layout and in improved methods. It is our belief that the opportunities for reducing costs through the use

of wage incentives *alone* are necessarily limited by the capacity of the operation as it stands or by the physical capacity of the operator; however the possibilities of diminishing expenses through the use of effective planning and layout and improved methods are almost infinite.

In order to take advantage of all opportunities for reducing the cost of labor through the use of the above-mentioned items, an amplified form of time study that properly emphasizes effective planning and layout and improved methods and at the same time determines the time values required by the different elements in the operation has been developed.

This new method of observation aids the analyst in the development of better job methods because it provides him with a simple and logical means of analyzing an operation. Through the use of common-sense rules and principles, it points out the ineffective work in the operation and at the same time indicates the cause and the correct means of removing that cause. Effective planning and layout and improved methods are thus properly stressed at the very start of a job analysis. Improvements in the operation lead-

ing to reduced costs are no longer haphazardly attained but are the cumulative result of logical and natural proceedings carried forward from the initial study of the operation.

Before proceeding further, it may be well to emphasize that the best feature of this form of study is that it develops ways and means of reducing the cost of labor, *not* by increasing the output at the expense of increased effort, but by increasing the output at the expense of wasted effort, through eliminating this wasted effort by effective planning and layout and improved methods.

II

THE FIRST DEGREE OF ANALYSIS

MUCH has been written about the origin of and the pioneers in motion study. Much more has been written about the application of motion study, and certain rules and principles have been formulated. However, when these rules and principles are analyzed and stripped of their verbal window dressing, we find that long ago people knew and applied them and that certain people were locally famous for their application. Even now, when we see motion pictures of the competition for the cornhusking championship held each fall somewhere in the Middle West, we see the results of this application of motion-study principles, applied by people who probably have never heard of the term. To them, their actions are the result of what they call "common sense."

It is our intention to present the subject of motion study in what we think is its most logical

form, without losing sight of common sense. Reduced to its essentials, motion study is nothing more than common sense expressed in written rules and principles so that there may be a meeting ground for those interested in reducing or eliminating wasted effort.

Even as a builder must lay the foundation upon which to erect his structure, so must we build a foundation upon which we shall construct the details of our motion studies. Our foundation, however, has several special requirements to fill, as follows:

1. It must be common to all operations.
2. It must be flexible enough to meet all conditions and variations found in the operations.
3. It must be simple.

When we have analyzed a number of operations, seeking the answer to these requirements, we reach the conclusion that all operations can first of all be broken down into two or more of the following basic elements:

1. A getting of the material or tool from some place or someone.
2. A temporary placing of this material or tool in some designated spot or position.

3. A processing of the material or a use of the tool.

4. A final placing of the (finished) material or (finished with) tool in some place (or with someone).

5. Delay.

This first breakdown we call the "First Degree of Analysis," and to the first four basic elements we assign the designation "Work Elements" and name them in order:

1. "Get."
2. "Place" (temporary).
3. "Process."
4. "Place" (final).

The "Delay" element will be considered later.

Before we go any further, let us define each of the "Work elements" so that we shall have a common basis for our judgments in future analyses:

"Get"

A "Get" element is that part, or section, of an operation used for the general purpose of getting control of a material or tool.

It usually begins with a movement of the

future controlling agent to the material or tool and does not end until the material or tool is under complete control. (A material or tool is under complete control only when free to move directly toward its intended location.)

Example: Operator reaches into the tote pan for one part. Parts are tangled together, and so he must separate the one part. The "Get" element is not completed until that one part is completely separated. (The movement of the future controlling agent was the movement of the hand to the tote pan.)

"Place"

A "Place" element is that part, or section, of an operation used for the general purpose of bringing a material or tool to a definite location.

It usually begins with a movement of the controlling agent to the general vicinity of the intended location of the material or tool and does not end until the controlling agent is entirely clear of the material or tool or any restrictions on or about it.

Example: Operator has the part held in tongs. He moves the part into the die nest, fits the part to the location pins, opens the tongs and moves the tongs clear of the part.

"Process"

A "Process" element is that part, or section, of an operation wherein the material undergoes a change in some characteristic or where a job requirement is satisfied.

Example: Operator has a drill point contacting a bar of cast iron. The "Process" element includes the action from the time the drill starts to cut until the drill breaks through on the opposite side and the drill bit is withdrawn (or until the hole is at the desired depth and the drill bit is withdrawn). This would be written as "Drill hole," and the size would be given.

Example: Operator has a soldering iron and a coil of solder at the joint to be soldered. The "Process" element would cover the actual soldering from the time the solder

was applied to the iron until the seam had been soldered, and would be written as "Solder seam."

Now that we have defined and given examples of the three "Work elements," let us consider some very simple operations and list the "Work elements" in them in their consecutive order; for instance, grinding the cutting edges of large-sized star drills, heavy enough to require the use of both hands. The analysis of the "Work elements" in this operation would be as follows:

Element No.	
1	Get drill from skid
2	Place edge against grinding wheel
3	Grind edge ("Process")
4	Place opposite edge against grinding wheel
5	Grind edge
6	Repeat elements 2, 3, 4 and 5 for each additional edge
7	Place finished drill on finished work skid

In the painting of some object with a spray gun the left hand holds the hoses during the entire operation. The analysis of the "Work elements" for the right hand would be as follows:

Element No.

1 Get spray gun
2 Place gun at proper spraying distance from object
3 Spray object ("Process")
4 Place gun in cup

As you have probably noticed, all the above examples are quite simple, but, as you become more familiar with the subject, you will soon perceive how this same form of breakdown applies to all operations.

To return to the definition of the "Get" element, we said that it usually began with a movement of the *future* controlling agent toward the material or tool and ended when the material or tool was under complete control. At that time we did not discuss what would constitute a controlling agent. As this point is open to many interpretations if qualifications are not added to the original statement, we must clear it up before going any further.

For instance, in the case of a steam shovel digging out gravel, the bucket controls the gravel within it, a cable controls the bucket, a motor controls the cable and a man controls the motor. Who or what is the controlling agent of

the gravel? Considering all angles to this type of problem as it applies to our everyday work, the answer is expressed in the following rules:

"The controlling agent of any object is the actual agent used to handle the object."

"When both a material and a tool are being acted upon at the same time, our analysis should show the results of the actions of the tool upon the material." (In special instances, such as a study of how a tool is handled, we show the results of the actions of the controlling agent of the tool.)

This means that, if we were to analyze the handling of the gravel mentioned above, we should determine what the actions of the bucket accomplished, but, if we were to analyze the operation of the steam shovel as a whole, we should determine what the actions of the operator accomplished.

These rules have an important bearing on the future improvement of the operation, as will be shown later.

III

THE SECOND DEGREE OF ANALYSIS

In our discussion of the First Degree of Analysis we defined a "Work element" as a series of actions that always accomplish the same general result. (For instance, all "Get" elements deal with getting control of some object, regardless of how that control is secured.) Our next finer degree of analysis, then, is to break each "Work element," or "general result of a series of actions," down into specific results. This next degree of analysis is called the "Second Degree of Analysis."

Starting the discussion of the Second Degree of Analysis with a breakdown of the "Get" element, we find that its actions, regardless of whether they are physical or mechanical, slow or fast, can always be classified into certain specific types:

1. Actions that move a controlling agent to a wanted object.

2. Actions that prepare the controlling agent to be able to obtain control of the wanted object (if necessary).

3. Actions that obtain complete control of the object.

We examine every "Get" element and find that it fits these qualifications. Therefore, this typing, or classification, of actions or movements according to what they accomplish becomes the second step in our analysis of the operation. In this step each action is placed under its proper classification according to which of the above specific purposes it accomplishes.

Before proceeding with this Second Degree, we must assign names, definitions and abbreviations to the various classifications as we encounter them.

For the "Get" element, we have the following classifications:

THE SECOND DEGREE OF ANALYSIS

Name	Abbreviation	Definition	Shown on pages 15 and 16 under
Transport Empty	T.E.	"Transport Empty" is the name of the classification used whenever an action *results* in moving a future controlling agent to, or to the vicinity of, a wanted object	(1)
Preposition......	P.P.	"Preposition" is the name of the classification used whenever an action *results* in preparing a future controlling agent (or the object under control) for the performance of some subsequent act	(2)
Grasp...........	G.	"Grasp" is the name of the classification used whenever the *result* of an action tends to bring an object under control. (This means that any movement caused by any hindrance to, or obstruction in the way of, a free access to an object is chargeable to "Grasp")	(3)

Following are several simple illustrations of these classifications as you will encounter them in the usual "Get" element.

Example: "Get nut."

An operator dismantling an assembly takes a nut off a stud with his fingers.

Description of Action	*Classification*
Move hand to nut so that fingers may be able to close on nut. . . . . (Move a controlling agent to a wanted object)	T.E.
Open fingers during travel of hand so that span between fingers is greater than span of nut. . (Prepare the controlling agent)	P.P.
Close fingers on nut Back nut off bolt as far as possible Open fingers Turn hand to get new hold on nut Close fingers on nut Back nut completely off bolt . . . . (Obtain *complete* control of the object)	G.

The actions within the brackets illustrate the meaning of complete control (see definition, section on "Work elements"). When the fingers

closed on the nut for the first time, the nut could not be moved directly toward its intended location (for instance, the top of a bench) until further actions cleared it from the threads on the bolt; therefore, these other actions were also charged to "Grasp" (see definition of Grasp).

Example: "Get skid."

A handler, with the aid of a jack-lift truck, raises a skid of work off the floor preparatory to moving the skid.

Description of Action	*Classification*
Move truck under skid	T.E.
(Move a controlling agent to a wanted object)	
Pull handle down, raising skid one notch Move handle up, setting jack at second notch Pull handle down, raising skid to second notch Move handle up, setting jack at third notch Pull handle down, raising skid to third notch	G.
(Obtain *complete* control of the object)	

This example is but a variation of the first with different materials.

Example: "Get stamping."

A punch-press operator, performing the trimming operation after a draw, gets the top piece from a stack of nested pieces.

Description of Action	*Classification*
Move tongs to lip of top piece	T.E.
Open jaws of tongs during travel to piece	P.P.
Close tongs on lip of piece Raise top piece off nested stack	G.

Undoubtedly, you can think of a multitude of "Get" elements, and if you analyze a few representative examples you will find that in the majority of cases they follow the above pattern. The other cases will also follow the same pattern but to a smaller degree, with perhaps one or more movements for some other classification in excess of the regular pattern of "Transport Empty," "Preposition" and "Grasp."

IV

MOTIONS

A PREVIOUS chapter explained how all operations are composed of some combination of the various "Work elements," which were defined and illustrated. The breakdown of an operation into these basic elements was called the "First Degree of Analysis."

Using the "Get" element as an illustration of a basic element, we have shown that all the basic "Work elements" are fairly well standardized within themselves. By standardized, we mean that each "Work element" may be broken down into smaller units, temporarily called "classifications," and that certain of these classifications would be found only in specific "Work elements." This means, of course, that if we determine the correct "Work element" we have practically specified the classifications within the element.

You can readily see that this procedure sets up first and second degrees of analysis. If we wish to cover only the high spots of the operation, we break it down into "Work elements." If the possible return is worth the added work required, we may use the Second Degree of Analysis by taking the "Work elements" and breaking them down into the various classifications.

Indirectly, we have already defined a "classification" as "the purpose accomplished by, or the result of, a physical or mechanical action or the lack of such action."

Therefore, the Second Degree of Analysis is the determination and classification of what is accomplished by the individual actions within the "Work element" under observation. To simplify matters, each classification of what is accomplished has a name based on its own characteristics and is defined (as illustrated in the section on the "Get" element) in order that it may always be used in the same manner.

Ordinarily, the general term for the various classifications of the results from the individual actions in an operation is "therblig." We prefer

to use the word "motion" because, when we say "motion study," we emphasize that we mean primarily the study of what the actions do, or accomplish, rather than a study of the actions themselves. It is the belief of the author, along with others, that, if we determine what the actual movements accomplish so that we may remove the cause (s) of the inefficient movements, the others will take care of themselves. Therefore, we replace the bulky title "classification" with the word "motion," taking over the definition of the latter at the same time. Thus, the definition of a "motion" becomes: "A motion is the purpose accomplished by, or the result of, a physical or mechanical action or the lack of such action."

V

THE "PLACE" ELEMENT

"Place"

A "Place" element is that part, or section, of an operation used for the general purpose of bringing a material or tool to a definite location.

First Degree of Analysis

In the short discussion of the "Place" element under the general heading of "Work elements," we mentioned that this element usually began with a movement of the controlling agent to the general vicinity of the intended location of the material or tool and did not end until the controlling agent was entirely clear of the material or tool or any restrictions on or about it. The words "general vicinity" are used intentionally to cover as many situations as possible. For instance, the controlling agent will often be able to move the object under control directly to its

intended location. Or, again, because of some characteristic of the operation, the controlling agent will be able to move the object under control only near its intended location and then will have to use extra movements to move the object to its *exact* intended location.

As examples of the above statements, let us consider two different operations, using an ordinary house key as the object. First, let us place the key on a table top. In this case the hand (the controlling agent) moves the key directly to its intended location. Placing the key anywhere within a radius of 2 in. of where we wish it to go would probably be entirely satisfactory. Secondly, let us insert the key into a keyhole. Unless you have unusually steady nerves, the usual procedure is to move the key directly to as close a position to the keyhole as possible and then, by a series of positioning movements, to bring the key into exact line-up with the keyhole. As you can see, both examples begin with a movement of the controlling agent to the general vicinity of the intended location of the material or tool, thus fulfilling the first qualification.

Our second qualification, *i.e.*, "and ends when the controlling agent is entirely clear of the material or tool or any restrictions on or about it," especially the latter part, is very important. It is just as well to mention now that one reason we stress the "restrictions on or about it" is to force the observer to classify any movements made to overcome or escape these restrictions as part of the wasted effort in releasing the object. As an example of restrictions let us consider the operation of closing a breechblock on a cannon. If the gun crew had to screw down the breechblock until the block was seated, the block having to travel the entire lead of the threads, the elapsed time per shot fired would be materially increased. As it is, there are lands cut in the breech to fit grooves cut in the breechblock, and the block travels along the lands until partially seated. It is then completely seated by engaging the threads of block and breech and screwing the block down tightly. Use of the land-and-groove idea has enabled the gun crew greatly to overcome the restrictions on relinquishing control of the breechblock caused by the necessary threading of the breech. Using

the same idea on a smaller scale, threaded-type locks on core boxes used on core blowers have been changed to land-and-groove type owing to the emphasis on the fact that the threaded construction of the lock restricted the controlling agent in the quick performance of its duties. Guided by this second qualification, the analyst classified the act of threading on the lock as restricting the quick disposal of the lock and proceeded accordingly.

Second Degree of Analysis

We are not so fortunate with the "Place" element as we were with the "Get" element. As was noted previously, the "Get" element is usually composed of one or more actions in order to "move a controlling agent to the desired object" (we called this accomplishment "Transport Empty"), one or more actions in order to "prepare the controlling agent to be able to control the desired object" (we called this accomplishment "Preposition") and one or more actions in order to "acquire complete control of the desired object" (we called this accomplishment "Grasp"). The "Place" element is similarly

composed of some sequence of actions for some two to four "motions," but, on the other hand, its "motions" are not necessarily in regular order. Three of its usual four "motions" are new, the other (P.P.) having been covered under the discussion of the "Get" element.

The "Place" element is made up of one or more actions that may be classified under the following types:

1. Actions that move an object directly to the vicinity of some predetermined location.
2. Actions that prepare the object under control for the performance of some subsequent act.
3. Actions that bring one object into line with some other object.
4. Actions that release the control of the object.

The motions, or classifications, of the results accomplished by such actions are named and defined as follows:

Name	Abbreviation	Definition	Shown on page 28 under
Transport Loaded	T.L.	"Transport Loaded" is the name of the classification used whenever an action *results* in moving an object to, or to the vicinity of, a predetermined location	1
Preposition......	P.P.	(See "Get" element)	2
Position.........	P.	"Position" is the name of the classification used whenever an action *results* in bringing one object into exact relationship with another	3
Release Load....	R.L.	"Release Load" is the name of the classification used whenever the *result* of an action tends toward losing control over an object	4

Their usual sequence is one or another of the following, with the most frequently used listed first and the others in consecutive order.

1. T.L., P. and R.L.
2. T.L. and R.L.

3. P.P., P. and R.L.
4. P.P. and R.L.

Other combinations are decidedly in the minority. However, the observer should be familiar with the "motion" definitions in order to recognize all combinations as encountered.

The following are several simple illustrations of the sequence of motions in the "Place" element.

Example: "Place screw in tapped hole."

Operator has screw between fingers, threaded end of screw down.

Description of Action	*Motion*
Move screw to directly above tapped hole......	T.L.
Line up end of screw with tapped hole Back up screw until threads of both screw and tapped hole line up	P.
Turn screw engaging threads of screw and tapped hole Open fingers, releasing screw	R.L.

Example: "Place label on box."

Operator holds glued label in fingers and has covered box on table top in front of him.

Description of Action	*Motion*
Move label to over top of box.	T.L.
Line up label to approximate center of box cover.	P.
Remove thumb from beneath label while pressing label against box top with fingertips.	R.L.

Example: "Place lift on square cutter."

Handling team has removed lift of paper from truck.

Description of Action	*Motion*
Move lift to square cutter shelf.	T.L.
Turn lift to place trim edge at back.	P.P
Shove lift to rear against back bar.	P.
Pull lift board out from beneath lift.	R.L.

These examples demonstrate but a small number of the "Place" elements that quickly come to mind. We suggest that you analyze several of the jobs with which you are familiar to see whether you can determine the "Place" elements and the motions that compose them.

VI

THE "PROCESS" ELEMENT

THE "Process" element, compared to the standardized "Get" and "Place" elements, is really nothing more than a convenient catchall for the performance of any work required by the manufacturing process itself. For instance, a man mixing cement by hand would "Get" and "Place" several layers of sand, lime and dry cement; "Get" and "Place" several pails of water; "Get" and "Place" his cement hoe and then "Process" the cement or, as we should actually describe it, "Mix cement." Similarly, a foundry molder will perform several "Process" elements during the making of a mold. The "Process" elements within the following short sections of his operation serve to illustrate the variety of work listed under this element:

1. "Get" jolt-control-valve handle.
2. "Place" jolt-control-valve handle in open position.

3. "Jolt" sand in flask ("Process").

or

1. "Get" hand rammer.
2. "Place" rammer.
3. "Ram" sand along edges of flask ("Process).

In the section on the First Degree of Analysis we gave a drill-press example to illustrate the "Process" element. We said that the work from the time the drill point contacted the piece until the drilling was finished and the bit withdrawn belonged under the "Process" heading. It and others of its type are undoubtedly clearer examples of the "work required by the manufacturing process" than either the "Mix cement" or the above molding examples; yet the latter are necessary processes in the making of the final product in their own fields.

The motions found within the "Process" element vary from element to element. The analyst, when encountering a "Process" element, must study it on its own merits and disregard any motion patterns encountered in previous "Process" elements.

VII

THE "DELAY" ELEMENTS
PHYSICAL TYPE

A First Degree of Analysis breakdown of an average operation is composed of some sequence of "Work elements" in occasional combination with interspersed "Delay" elements. The "Delay" elements have nothing in common with the "Work elements." As the name implies, they are the direct opposite. They cover those sections of the operation where no value is added to the part, because of a lack of action.

There are two classes of "Delay," physical delay and mental delay. Ordinarily, physical delay is caused by the layout of the operation, lack of training in the correct method or lack of normal effort on the part of the operator. The first two items cause the same types of "Delay" elements and will be considered together. The last item, considered a "Delay" element in itself, is called "Avoidable Delay" and will be considered later.

The "Delay" elements caused by the layout of the operation or by lack of training in the correct method are as follows:

"Delay" element	Abbreviation	Definition
Hold...............	H.	The name of the classification used whenever a lack of action results in keeping an object in a temporarily immovable (or nearly so) position
Unavoidable Delay.	U.D.	The name of the classification used whenever a lack of action outside the control of the operator is encountered

A simple example of "Hold" can probably be found by everyone without much trouble, but to illustrate the combination of "Work elements" and "Delay" elements, we give the following example:

Operator's job is to solder joint between water tank and radiator core. The parts are in a solder-

ing jig and are in working position. The flux has been applied to the joint. Operator proceeds as follows:

Left	Right
Get end of coil of solder.	Get soldering copper.
Wait for temperature test (Delay element).	Plunge copper in liquid flux to test temperature (Process).
Place end of coil of solder against proper face of soldering copper.	Place copper at starting point of joint.
Hold end of solder against copper (Delay element).	Solder joint (Process).
Feed more solder to soldering face of copper (Process).	Solder joint (continued).

We should like to point out that the "Wait for temperature test" is charged to U.D. (that delay outside the control of the operator), instead of to "Hold solder," because it was caused by the present layout of the operation, wherein

it is necessary to wait for the temperature test, rather than by the need to support the solder. At the present time it may seem immaterial what name we give the "Delay" as long as we recognize it, but in later sections we shall find that correctly classifying the "Delays" will aid us considerably in improving the operation (also true of "motions," as pointed out previously).

"Avoidable Delay" (A.D.) has many synonyms. Some of them are "soldiering," "operator idle" (not allowable), "W.P.A.," and a host of others. There are many different ways of saying it. Essentially, this element covers all operator-idle time (except personal) that he or she is able to control. It is frequently encountered and, if a regular occurrence, should be listed in its proper sequence. Otherwise, it should be disregarded and left out of the usual sequence of "Work" and "Delay" elements.

VIII

THE ANALYSIS SHEET

When one has become sufficiently familiar with the definitions of the various "Work elements" to undertake a first-degree analysis, it becomes necessary to set up a means of recording the elements and their sequence in an operation. This recording means is illustrated opposite and is entitled "Analysis of Operation." The information contained in the heading of the analysis sheet is the usual commonplace information, serving mostly to tie the analysis back to the actual operation.

The body of the analysis sheet is set up to cover elements performed by either the right or left side of the body, separately or together. Elements performed solely by the right side of the body are listed under the column entitled "Right," the wording of the element starting at the center line and not passing the column rule at the right side of the sheet (see example *A*,

ANALYSIS OF OPERATION

Dept................		......Sheet of.......
Supervisor...........	Title....................	Date................
Operator.............	Product.................	Elapsed Time.........
Observer.............		

Extension	Element times	Left	Right	Element times	Extension
			(*A*) Get spray gun from holding cup on wall of spray booth	(*D*) .0150	
	(*D*) .0150	(*B*) Get spray gun from holding cup on wall of spray booth			
	(*E*) .0120	(*C*) Get large-size star drill from skid at right		(*E*) .0120	
	.0090	Wait	Get fountain pen from upper left coat pocket	.0090	
(*F*) .0290	.0200	Get end of barrel (unthread and clear from cap)	Place pen in front of operator	.0040	(*F*) .0130
			Hold cap	.0160	(*F*) .0290

page 39). The same holds true for elements performed solely by the left side of the body, only in this case the wording of the element begins at the column rule at the left side of the sheet and does not pass the center line of the sheet (see example *B*). If the element is per-

formed by both sides of the body together, the element is written across the center line of the sheet, extending into both "Right" and "Left" columns (see example *C*).

The time for each element is listed in the "Element times" column, either on the right or left side of the sheet depending on which side of the body performed the element (see example *D*). If performed by both sides of the body together, the time is listed in both right and left "Element times" columns (see example *E*). The method of determining these times will be discussed in later sections. The extension columns serve to accumulate the elapsed times as each element is added to the analysis (see example *F*).

The procedure in using the Second Degree of Analysis is to determine the "Work element" in the manner described in previous sections and to list it on the analysis sheet. Then under this "Work element" list the symbols for the "motions" pertaining to the element in vertical sequence, indented to show that they belong to that "Work element." This procedure continues for the entire operation as shown on page 41.

ANALYSIS OF OPERATION

Dept................		......Sheet of......
Supervisor...........	Title..Assemble One Screw..	Date................
Operator.............	Product..................	Elapsed Time........
Observer.............		

Extension	Element times	Left	Right	Element times	Extension
	.0060	Place screw driver aside (after driving previous screw) T.L.	Get screw from tote pan on bench T.E. G.	.0220	
.0460	.0400	Hold screw driver (delay)	Place screw in tapped hole T.L. P. R.L.	.0240	.0460
.0520	.0060	Place screw driver over screw T.L.	Get screw driver by slip sleeve T.E. G.	.0060	.0520
.0695	.0175	Hold screw driver (delay)	Place screw driver bit in slot of screw T.L. P.	.0175	.0695
.1095	.0400	Operate ratchet screw driver T.L.	Hold slip sleeve (delay)	.0400	.1095

As listing these "motions" under the "Work elements" tends to expand the analysis sheet, the device of drawing a wavy line under "Delay" elements is used in actual practice to denote the fact that the "Delay" element is completed at about the same time as the

"motion" listed on the opposite side of the analysis sheet. This device serves to emphasize the duration of the "Delay" elements.

The times shown in the example of "Assemble One Screw," page 41, are for illustrative purposes only and do not necessarily hold true for the actual operation.

Both for the sake of appearance and for better comprehension of the balance of the various "Work" or "Delay" elements on one side of the sheet with those on the other side, it is recommended that, when an element is performed by one side of the body simultaneously with an element performed by the other side of the body, they be listed even with each other on the analysis sheet.

IX

OCCASIONAL MOTIONS

Often in making a second-degree analysis of an operation, the observer will encounter individual motions, ordinarily a component of some one of the "Work elements," not conforming to the definition of any of the elements. For instance, "Release Load," usually a component of the "Place" element, may be found interspersed between several consecutive "Place" elements, yet obviously not a component of any of them. Similarly, any motion may thus be encountered. The individual motions so found are called "occasional motions," and their treatment is discussed in this section.

Technically speaking, an occasional motion is a part of some "Work element," but through some circumstance such as the intervening of a "Delay" element it has become separated from the major portion of the "Work element" and only through a liberal use of the imagination can now be connected with the original element.

For an example, let us use a section of a simple operation with which most of us are familiar. Most of us use a fountain pen, and when we wear our coats we usually have it in the upper left coat pocket. Midway in the operation of removing the pen from the pocket, uncapping it and preparing to write, we encounter this section. The right hand is holding the cap with the opening to the left. The left hand is holding the barrel with the nib to the right. We proceed from this point as follows:

Motion	Description	Description	Motion
	Place barrel into cap, nib to left	Hold cap	H.
P.P.	Rotate barrel 180 deg.		
T.L.	Move end of barrel to opening in cap		
P.	Position end of barrel to opening		
R.L.	Move barrel into cap		
	Hold barrel of pen	Get pen in writing position	
H.		Release cap	R.L.
		Move fingers to barrel	P.P.
		Close fingers on barrel	G.
	Release barrel	Hold pen	H.
R.L.	Open fingers		

The "Release Load" last listed on the left side of the example cited is an occasional motion. In its present position it does not fit the definition of any of the "Work elements." However, if we were to disregard the intervening "Hold," we should find that it really belongs to "Place barrel in cap." But as our analysis is taken in sequence from the beginning of the operation and we list our "Work" and "Delay" elements in the order in which they occur, we cannot be continually looking ahead to see whether there might be some separated part of a "Work element" to be included under its proper classification. If there is, we list it in its sequence as an occasional motion, as discussed and illustrated in this section.

X

THE "DELAY" ELEMENTS MENTAL TYPE

The field of mental delay is a varied one. However, it can be divided into two classes. First, the mental delay caused by sensory impressions and, second, the mental delay caused by thinking or reasoning.

Fortunately, the receiving of sensory impressions and the attendant mental delay may be measured upon standardization, in the same manner as physical operations. It is believed that the reaction to these sensory impressions becomes a habit just as physical movements well learned become a habit, provided that the causes of the sensory impressions are kept within easily remembered limits. In other words, if our job is inspecting the surface of flat sheets and if upon encountering a marking of some sort we find that the marking is standardized

and easily remembered, our decision is automatic. We make up our mind immediately as to whether it goes or does not go. On the other hand, if the marking is unusual, we depart from the field of automatic reactions and enter the field of thinking, or reasoning, which varies with the individual and does not lend itself to standardization.

The mental delay in the production-type job, due to its standardization, usually falls in the sensory class. The simplest type of inspection, where the sole duty is either to pass or to reject articles according to measurements of certain dimensions or to surface quality where the defects are easily remembered, also belongs to this class. More complicated inspection, such as the final passing on an assembled radio chassis, where almost any defect is likely to appear but never twice in a row, and the mental delay encountered in jobbing-type operations fall into the second class.

Although the following "Delay" elements are technically applicable to both classes, we shall concentrate on the ones usually associated with the sensory-impression type of mental delay

and barely mention the others except to name and define them.

"Delay" element	Abbreviation	Definition
Inspect..........	I.	The name of the classification used whenever an action results in determining the presence or absence of predetermined characteristics
Select...........	Se.	The name of the classification used whenever an action results in making a choice between two or more objects in a known location
Search..........	S.	The name of the classification used whenever an action results in determining which of several possible locations contains the desired object

The following is an illustration of a typical example of "Inspect" showing the different

actions of both sides of the body. The description of the action is written in so that the reader may better follow the job.

Motion	Description	Description	Motion
Get inspected shaft from jig		Get commutator shaft from tote pan	
T.E.	Move hand to shaft	Move hand to shaft	T.E.
G.	Close fingers on shaft	Close fingers on shaft	G.
Place shaft in finished-work tote pan (either "good" or "reject")		Place shaft in gaging jig	
T.L.	Move shaft to proper pan	Move shaft to jig	T.L.
		Line shaft up with jig	P.
R.L.	Raise thumb from side of shaft, shaft dropping onto top tier of finished work	Push shaft home in jig	R.L.
		Open fingers	R.L.
R.L.	Roll shaft against next shaft in line		
Wait for inspection		Inspect shaft	I.
U.D.		Examine gages as shaft is rolled backward and forward by palm of hand	

You might question why we list "Inspect," a "Delay" element, as the last item on the right side of the above example, as there are the several physical movements of rotating the shaft

taking place at that time. The answer is that a "Delay" element does not imply a lack of physical movement but a lack of movement through space on the part of the object. Besides, the reason that the physical movements were made was to aid in the inspection of the shaft; so, naturally, they are listed under "Inspect."

"Select," as we use it, is rare. Nowadays, with parts manufactured in quantity lots and kept to common limits during manufacture, it is seldom necessary to select one part as being better adaptable to some particular use than other parts of the same type. However, "Select" is found quite often in jobbing-type operation. A good example would be that of an automobile mechanic choosing one feeler gage from several in order to test the clearance between tappet and valve. It may also be found quite often in foundry core making and molding operations, where the selection of the type of nail, rod, or wire used to support the core or mold depends to a great extent upon the condition of the individual core or mold.

"Search," in the average production-type operation, has almost completely disappeared.

Manufacture of products in volume sufficient to permit the breakdown of the manufacturing cycle into several smaller, repetitive units has enabled supervision to reduce the number of tools and parts handled per operation. This allows the proper segregation of the tools and parts, thus enabling the operator to memorize the location of each.

If either "Select" or "Search" is found in the operation under study, it is our recommendation that it be corrected immediately before proceeding further. There are two major reasons for this procedure. First, because nowadays it is suspicious and it may have been introduced only for the duration of the study and, second, because it is almost impossible to assign a consistent time value to the conglomeration of movements and delays making up these "Delay" elements.

XI

TIMING THE OPERATION—I

We have now set up a means of analyzing operations for the "results" of various subunits, depending upon the degree of detail wanted. Our next step is to determine the elapsed time of these subunits, also depending upon the degree of detail wanted.

Our analysis of the effectiveness of an operation consisted of two successive steps, as follows:

1. The breakdown of the operation into "Work" and "Delay" elements.

2. The breakdown of the "Work elements" into "motions."

The cost value, or worth, of the operation, however, is based upon the amount of time required to perform it. Therefore, on a comparable basis, the value of each successive step in our breakdown must also depend upon the amount of time it requires.

Ordinarily, in taking time studies elements finer than .04 to .05 min. are not practical

because the usual type of stop watch, graduated in hundredths of a minute with the large hand making one revolution in one minute, does not permit of any smaller units for direct reading. This form of time study does not lend itself to our purposes because the usual individual "Work element" seldom reaches the magnitude of .04 to .05 min., and if the use of this type of watch is to be continued several "Work" or "Delay" elements must be combined in order to make one so-called "Time-study element." The question would then arise—if we cannot time one individual "Work element" and definitely establish its value, why bother with such a fine breakdown? The answer is that we must use some other means of timing that permits smaller readings than the hundredth-of-a-minute watch.

At the present time there are three of these timing devices in fairly common use. These devices are:

1. The high-speed camera.
2. The split-hundredth watch.
3. Time formulas for physical movements.

Each of these devices has its own particular field. For instance, the high-speed camera is

used extensively in the field of micromotion, wherein the operation is analyzed from its picture, and the time required is determined by the number of frames of film between selected points. Our need, however, is a timing device with readings that are instantly obtainable, and as we already have a means of analysis the camera does not appear suitable.

The use of time formulas for physical movements requires a breakdown showing every physical movement used in the operation. Naturally, this sort of breakdown requires more time on the part of the analyst than any other form of original study and thus requires a greater yearly pay roll on the operation or a higher per cent of potential savings in order to justify the greater amount of investment in the original study.

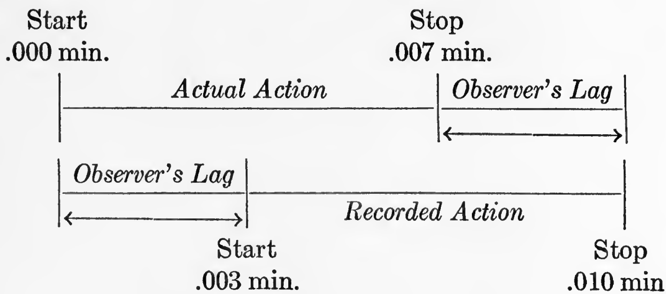
The direct value of time formulas for physical movements is that every movement in the operation is assigned a specific amount of time. Eliminated movements can therefore be directly subtracted from the original total time, resulting in an expected time for the improved, or the rearranged, operation. A more important value,

although more intangible, is that the investigation of every physical movement used cannot fail to convey to the analyst some of the reasons why those movements are necessary and thus to give him a more solid foundation for instigating improvements.

The split-hundredth stop watch is a watch that has the large hand make one revolution around the dial in $^{10}/_{100}$ of a minute (6 sec.). With the dial marked in the usual hundredth-of-a-minute watch fashion, each marking represents $^{1}/_{1000}$ of a minute. With this watch it is possible to time sections of operations as short as .006 to .007 min. Of course, this requires a snap-back type of study on those sections and continual alertness on the part of the observer in making sure that there is no overlap of other sections of the operation into the section being timed.

Naturally, on such short elements there is a lag between the instant the operator begins or stops the action and the start or stop of the watch because of the mental and muscular time-consuming actions of the observer in recognizing these points and actuating the stop watch. This

lag does not prevent the determination of accurate time values, as illustrated by the following diagram:



The elapsed time in both instances is .007 min. If time values smaller than .006 to .007 min. are needed, the method of timing different combinations of elements and subtracting out the desired elements can be used, just as with the regular type of watch.

The usual method of speed rating is used with the time values derived by this type of study, thus converting the actual time values into standard, or allowed, values.

The split-hundredth watch, therefore, partially fills our needs in that we can obtain readings as low as .006 to .007 min.; it fits in with

our present time-study methods; it is much faster for comparable results than either of the other timing methods; and it will cover about 95 per cent of the individual "Work elements" encountered. The finer breakdown of "Work elements" into motions does not require timing, as the time of the "Work element" itself is sufficient in this type of breakdown.

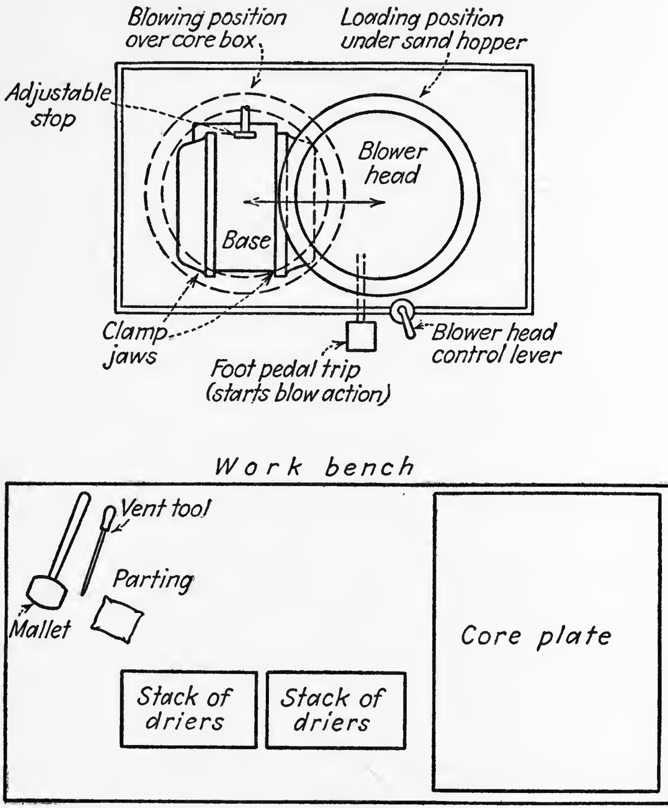
Summing up the question of determining time values only, the usual type of stop watch is not suitable because it does not allow a sufficiently fine breakdown of the time values of "Work" or "Delay" elements; the micromotion camera provides a minute breakdown but is expensive both in cost of equipment and in time involved in analyzing the pictures (estimated at 1500 per cent of the time required of an ordinary time study), usually making the cost of study prohibitive except on products of large volume; time formulas for physical movements require the expenditure of considerably more time on the part of the analyst in making the original studies (estimated at 1000 per cent of the time required to make an ordinary time study), also usually labeling the cost of study prohibitive except on

products of large volume: whereas the split-hundredth stop watch can directly time 95 per cent of the "Work" or "Delay" elements, which is sufficient for our purpose and requires about 200 per cent of the time required to make an ordinary time study.

The value of a minute breakdown of the operation, experience quickly shows, is that the greater part of an operation's potential savings from improved methods can be realized by eliminating, in the following order: (1) the "Delay" elements, as shown in the First Degree of Analysis; (2) the ineffective motions, as shown in the Second Degree of Analysis.

It is admitted that eliminating the ineffective motions requires a knowledge of the physical, or mechanical, actions involved in performing the ineffective work. However, we shall show that the improvement principles tied in with the various motions, and the motions themselves, are so standardized that a knowledge of the number of physical, or mechanical, actions used, including their individual time values, is usually unnecessary except as an aid in predicting the expected time of the improved operation.

For instance, we know that all actions tied up with "Position" should be eliminated, and so we are going to try first to devise an improvement that will eliminate them all. If this is impractical, we shall try one that will eliminate most of them. If the number of actions involved in this "Position" are few and if we have not been able to eliminate them all, it soon becomes evident during the designing stage that the work involved is to no purpose, and this part of the operation is passed over in favor of more lucrative parts. Therefore, we need not and do not study movement detail in our analyses.



Original layout of core-blowing operation.

XII

TIMING THE OPERATION—II

In order to illustrate the recommended method of determining the time values for the various "Work" and "Delay" elements, a core-blowing operation will be analyzed and timed in its original form and then in a later section will be improved according to specific suggestions that tie in with the various motions.

The operation consists of blowing a two-piece, four-cavity, vertically split core box, venting each core individually, drawing the box from around the cores, placing the cores on a drier, placing the loaded drier on a carrying plate, dusting the box and reassembling the box.

A layout of the original equipment and their relative positions is shown opposite and a "First Degree of Analysis" breakdown follows:

<table>
<tr><th>Left</th><th>Right</th></tr>
<tr><td colspan="2">Get loaded box from clamp jaws
Place box on bench (turn 180 deg.)</td></tr>
<tr><td>Wait</td><td>Get vent tool (a length of $\frac{3}{16}$-in. rod with a handle on one end)
Place at core 1 and vent core (insert rod in core creating an opening) (A)
Repeat (A) for cores 2, 3 and 4
Place vent tool aside
Get box by top overhang</td></tr>
<tr><td colspan="2">Place box flat on bench</td></tr>
<tr><td>Hold box</td><td>Get mallet
Rap box
Place mallet aside</td></tr>
<tr><td>Unlock left lock</td><td>Unlock right lock (swing lock tongue clear)</td></tr>
<tr><td>Get box at pivot point of left lock</td><td>Get box at pivot point of right lock</td></tr>
<tr><td colspan="2">Draw No. 1 piece of core box (lift box piece off cores)
Place No. 1 piece of box on bench, inner side up (rotate 180 deg.)</td></tr>
<tr><td>Wait
Get opposite end of drier</td><td>Get drier from pile (by end)
Place drier above exposed cores</td></tr>
</table>

<table>
<tr><th>Left</th><th>Right</th></tr>
<tr><td colspan="2">Place drier on cores</td></tr>
<tr><td>Get adjoining left ends of drier and box</td><td>Get adjoining right ends of drier and box</td></tr>
<tr><td colspan="2">Place box drier side down (rotate 180 deg.)</td></tr>
<tr><td>Get lock flanges of box</td><td>Get lock flanges of box</td></tr>
<tr><td colspan="2">Draw No. 2 piece of core box (lift box piece off cores)
Place No. 2 piece of box on bench, inner side up
Get loaded drier
Place drier on carrying plate</td></tr>
<tr><td>Wait</td><td>Get bag of parting compound
Dust inner surfaces of both box pieces
Place bag aside</td></tr>
<tr><td colspan="2">Get No. 1 piece of core box
Place No. 1 piece on No. 2 piece
(rotate No. 1 piece 180 deg.)</td></tr>
<tr><td>Lock left side</td><td>Lock right side</td></tr>
<tr><td colspan="2">Get box by top overhang
Place box in core blower (turn 180 deg.)</td></tr>
<tr><td>Wait</td><td>Operate blower-head control handle</td></tr>
<tr><td colspan="2">Wait for blower head to move to blowing position</td></tr>
<tr><td>Wait</td><td>Operate foot pedal</td></tr>
<tr><td colspan="2">Wait for blowing period
(Release blower-head control handle)</td></tr>
</table>

There are two operators working full time on this operation, and so it will be worth our while to time this operation by individual elements. We assign symbols to these elements and line up our time study as follows:

Symbol	From	To
A	Beginning of reach for box in machine	Point when box clears machine
B	Beginning of move of box to bench	Point when box is settled on bench
C	Beginning of move to vent tool	Point when tool is ready to move to core box
D	Beginning of move to core box	Point when vent tool clears core No. 1 after venting
E	End of element *D*	Point when vent tool clears core No. 2 after venting
F	Beginning of move of vent tool to bench	End of grasp of lock flanges
G	Beginning of move to lay box flat on bench	Point when box is settled on bench
H	Beginning of move of hand to mallet	Point when control of mallet has been lost in replacement of mallet
J	Beginning of move of hands to locks	Point when locks are swung clear

Symbol	From	To
K	Beginning of move of hands to lock flanges	End of placing piece of box on bench, inner side up
L	Beginning of move to drier	End of clearing drier from others on plate
M	Beginning of move to core box	Point when drier is perfectly settled on cores
N	Move of hands to end of drier and box	Point when box is completely settled on bench
P	Beginning of move to lock flanges	End of placing piece of box on bench, inner side up
Q	Beginning of move to loaded drier	End of settling drier on plate
R	Beginning of move to bag	End of replacing bag
S	Beginning of move to No. 1 piece	End of placing No. 1 piece
T	Beginning of move of hand to lock	Point when locks are securely fastened
U	Beginning of move to overhang	Release of box when in machine
V	Beginning of move of hand to blower-head control handle	End of waiting for head to move to blowing position
W	Beginning of move of foot to pedal	End of blowing period
X	End of blowing period	Point when blower head is clear of box

This analysis is not fully written down on the time-study sheet but is shown here as an attempt to portray the thinking of the observer as he lines up the time-study elements.

The actual timing may now begin. Other than stating that the timing must be done by the snap-back type of study, using the split-hundredth watch, we shall leave the number of readings required, the method of rating, etc., for the observer to fit in with his regular methods of study.

An example of times likely to be recorded on some of the shorter elements of this job follows:

Element	Readings									
A	.014	.016	.019	.011	.016	.015	.012	.011	.015	.014
E	.016	.018	.014	.016	.018	.020	.015	.018	.015	.014
J	.008	.010	.007	.010	.009	.008	.012	.008	.009	.007

Using a selected reading from the time study for all the elements from *A* to *X*, we have, then, for our First Degree of Analysis:

Extension	Element times	Left	Right	Element times	Extension
	.014	Work (*A*)		.014	
.034	.020	Work (*B*)		.020	.034
		Delay	Work (*C*)	.006	.040
			Work (*D*)	.011	.051
			Work (*E*) × 3 occurrences	.045	.096
.107	.073		Work (*F*)	.011	.107
.137	.030	Work (*G*)		.030	.137
.179	.042	Delay	Work (*H*)	.042	.179
.194	.015	Work (*J*)	Work (*J*)	.015	.194
.249	.055	Work (*K*)		.055	.249
.261	.012	Delay	Work (*L*)	.012	.261
.293	.032	Work (*M*)		.032	.293
.310	.017	Work (*N*)		.017	.310
.365	.055	Work (*P*)		.055	.365
.390	.025	Work (*Q*)		.025	.390
.435	.045	Delay	Work (*R*)	.045	.435
.453	.018	Work (*S*)		.018	.453
.473	.020	Work (*T*)	Work (*T*)	.020	.473
.503	.030	Work (*U*)		.030	.503
		Delay	Work } (*V*)		
.528	.025	Delay } (*V*)		.025	.528
.578	.050	Delay (*W*)		.050	.578
.598	.020	Delay (*X*)		.020	.598

Out of a total of 1.196 min. of potential activity (2 × .598), .362 min., or 30 per cent, is delay, and .056 min. (elements *D* and *E*), or 4.7 per cent, is work over the same repetitive path. If nothing more is improved than these two outstanding items, there is a possible savings of approximately 35 per cent to be realized. However, after the discussion of the general

improvement suggestions, we shall take this same operation and by acting on those suggestions improve it wherever practical.

The following Analysis of Operation shows the final form of our study of the original operation.

ANALYSIS OF OPERATION

Dept. . Coremaking. . . . 1. . Sheet of. . 2. .
Supervisor. . J. Brown Title. . Blow Core Box and Draw Cores Date. . 4/29/42. . .
Operator. . . . R. Leach Product. . No. 424 Cylinder. . . . . Elapsed Time .598
Observer. . . . E. Stowe

Extension	Element times	Left	Right	Element times	Extension
	.014	Get loaded box from clamp jaws		.014	
.034	.020	Place box on bench (turn 180 deg.)		.020	.034
		Wait	Get vent tool		
			Place vent at core No. 1 and vent core	.017	.051
			Vent cores No. 2, 3 and 4	.045	.096
			Place vent aside		
.107	.073		Get box by top overhang	.011	.107
.137	.030	Place box flat on bench		.030	.137
		Hold box	Get mallet		
			Rap box	.042	.179
.179	.042		Place mallet aside		
.194	.015	Unlock left lock	Unlock right lock	.015	.194
		Get box at pivot point of left lock	Get box at pivot point of box		
.249	.055	Draw No. 1 piece of core box		.055	.249
		Place No. 1 piece of box on bench, inner side up (rotate 180 deg.)			
.261	.012	Wait	Get drier from pile (by end)	.012	.261
		Get free end of drier	Place drier above exposed cores		
.293	.032	Place drier on cores		.032	.293

ANALYSIS OF OPERATION

Dept...Coremaking ..2..Sheet of..2..

Supervisor........ Title..Blow Core Box and Draw Cores Date..4/29/42...

Operator.......... Product..No. 424 Cylinder.......... Elapsed Time....

Observer..........

<table>
<tr><th>Extension</th><th>Element times</th><th>Left</th><th>Right</th><th>Element times</th><th>Extension</th></tr>
<tr><td rowspan="2">.310</td><td rowspan="2">.017</td><td>Get adjoining left ends of drier and box</td><td>Get adjoining right ends of drier and box</td><td rowspan="2">.017</td><td rowspan="2">.310</td></tr>
<tr><td colspan="2">Place box on bench, drier side down (rotate 180 deg.)</td></tr>
<tr><td rowspan="3">.365</td><td rowspan="3">.055</td><td>Get lock flanges of box</td><td>Get lock flanges of box</td><td rowspan="3">.055</td><td rowspan="3">.365</td></tr>
<tr><td colspan="2">Draw No. 2 piece of core box</td></tr>
<tr><td colspan="2">Place No. 2 piece of box on bench, inner side up</td></tr>
<tr><td>.390</td><td>.025</td><td colspan="2">Get loaded drier
Place drier on carrying plate</td><td>.025</td><td>.390</td></tr>
<tr><td>.435</td><td>.045</td><td>Wait</td><td>Get bag of parting compound
Dust inner surfaces of both box pieces
Place bag aside</td><td>.045</td><td>.435</td></tr>
<tr><td>.453</td><td>.018</td><td colspan="2">Get No. 1 piece of core box
Place No. 1 piece on No. 2 piece (rotate No. 1 piece 180 deg.)</td><td>.018</td><td>.453</td></tr>
<tr><td>.473</td><td>.020</td><td>Lock left side</td><td>Lock right side</td><td>.020</td><td>.473</td></tr>
<tr><td>.503</td><td>.030</td><td colspan="2">Get box by top overhang
Place box in clamp jaws (turn 180 deg.)</td><td>.030</td><td>.503</td></tr>
<tr><td rowspan="3">.528</td><td rowspan="3">.025</td><td>Wait</td><td>Operate blower-head control</td><td rowspan="3">.025</td><td rowspan="3">.528</td></tr>
<tr><td colspan="2">Wait for blower head to move to blowing position</td></tr>
<tr><td>Wait</td><td>Operate foot pedal</td></tr>
<tr><td>.578</td><td>.050</td><td colspan="2">Wait for end of blow (release blower-head control)</td><td>.050</td><td>.578</td></tr>
<tr><td>.598</td><td>.020</td><td colspan="2">Wait for blower head to clear box</td><td>.020</td><td>.598</td></tr>
</table>

XIII

COMBINING "WORK ELEMENTS" FOR TIMING PURPOSES

HERETOFORE the various "Work" and "Delay" elements have always been illustrated to the Second Degree of Analysis. This has been necessary in order to train the reader in the correct way of analyzing an operation, because one of the two degrees of analysis is *always* used and recorded regardless of how coarse or how fine the degree of timing. In other words, we shall always first analyze the operation by using one of the degrees of breakdown and then time it according to whatever degree is deemed necessary.

Mention has already been made of the recommended method of timing "Work" or "Delay" elements and their various components. Many times, however, it is not profitable to go into so much detail as the timing of even the "Work elements" involves, and it is necessary to combine several "Work elements" into one so-called

"Time-study" element. Should this be so, there are several special conditions to be observed in order to set up a consistent method of timing for all observers. These conditions are as follows:

1. If possible, combine the "Get" and the "Place" elements of the same article and, if there is a "Process," keep it separate.

2. If it is impossible or uneconomical to separate the "Process," combine the "Get," "Place" and "Process" elements of the same article.

3. If the two conditions mentioned above are still in too much detail for the job in question, combine the "Get," "Place" and "Process" elements of two, and occasionally three, articles, preferably those that are used in conjunction with each other, such as two parts that are assembled together.

It is not often wise to combine further than described in condition 3 because (1) it permits the introduction of accumulative errors; (2) it prevents the determination of standard times for standard elements.

As you undoubtedly know, it is rare that two or more observers independently observing the same or similar operations on different occasions

will break the operation down into the same elements. Direct comparison and adjustment, therefore, are extremely difficult.

It is the purpose of the preceding three conditions to standardize, as far as possible, the latitude permitted an observer in setting up those "Time-study" elements that are combinations of two or more "Work elements."

The rating of the operator, the number of readings per element and the method of timing, whether continuous reading or snap back, will be left to the observer's judgment. However, the observer will soon find that continuous reading will be well-nigh impossible for all degrees of timing except those mentioned in conditions 2 and 3.

XIV

IMPROVING THE OPERATION—I

Now that ways and means of analyzing an operation for the *reasons why* the various movements are made have been provided and the time values of either individual elements or groups of elements have been determined, we come to the final stage, *i.e.*, the proper use of the foregoing information.

First, let us determine our goal. For instance, if every operation were to be set up under ideal conditions, we should find that the different "Work elements" would contain only certain motions and that some of these motions would contain but one movement each. The "Get" element would be composed of one movement each for "Transport Empty" and "Grasp." The "Place" element would be composed of one movement each for "Transport Loaded" and "Release Load." The "Process" element may have several movements but only for "Transport Loaded." All other movements, regardless of

motion, would be in excess and, if found, would be considered as wasted effort.

Under ideal conditions each part, tool or article handled should be convenient for the operator, both in going to it and in bringing it to the work place; the tools should be so arranged as to be instantly grasped and instantly released. Our purpose, then, is to come as near to this ideal setup as is warranted under existing conditions.

The first step is to classify the components of the operation under one of two headings, *i.e.*, useful effort or wasted effort. This classification is by motions, one set of motions belonging to the useful-effort group and the others belonging to the wasted-effort group. However, there are two motions, "Grasp" and "Release Load," that under certain conditions belong to both, as noted below:

Useful Effort	*Wasted Effort*
Transport Empty	Preposition
Grasp—the actual grasping of the article	Grasp—all movements in excess of the actual grasping of the article
	Hold

Useful Effort	*Wasted Effort*
Transport Loaded	Release Load—all movements in excess of the actual releasing of the article
Release Load—the actual releasing of the article	Position
	Unavoidable Delay
	Inspect—when physical movement is delayed
	Search
	Avoidable Delay
	Select

As mentioned previously, the breakdown of the "Work" or "Delay" elements into motions is really the basis of any future job improvement. After first separating the work into useful or wasted effort by the above breakdown, we use this separation to aid us in eliminating, or reducing, the wasted effort. This aid is in the form of groups of improvement suggestions. Each different group of suggestions pertains to one of the motions listed above under the wasted-effort column. Thus, by correctly classifying the motion while making our original analysis, we have but to consult the improvement suggestions for that motion in order to get some

proved ideas as to ways and means of eliminating, or greatly reducing, the wasted effort found in the original operation.

At this point we may say that the analysis of the original operation is complete. From now on our discussions will be devoted to improvement of the original operation, based upon our previous findings.

Briefly reviewing our steps in analyzing an operation, we have determined the "Work" and "Delay" elements making up the operation, we have classified the motions in these "Work" or "Delay" elements, we have noted the actual movements used, we have assigned time values to the elements and, finally, we have separated the motions into the sheep and the goats, or into useful or wasted effort. Our next step is to set forth suggested ways and means of eliminating such lost time as may be found in the original analysis of an operation.

XV

IMPROVING THE OPERATION—II

THE discussion of the following motions, all listed under Wasted Effort in the previous chapter, is confined to general suggestions. Obviously, there can be no set rules for eliminating wasted effort, as its cause will vary from job to job. However, the wasted effort in an operation can usually be taken care of by an adaptation of one of the suggestions listed below under their respective motions.

The most important factor in the successful use of these suggestions is the recognition of the true cause of the wasted effort. As the analyst becomes more proficient in the use of motion study, the analysis divides itself into two parts. First, the recognition of the reasons for the wasted effort under the present setup of the operation and, second, the listing of the effect of the waste on the operation through entries on the analysis sheet. Once the analyst has arrived at this stage, the following suggestions serve

but as reminders of what has successfully been used elsewhere.

"Preposition"

"Preposition" is defined as "the classification used whenever an action prepares a future controlling agent (or the object under control) for the performance of some subsequent act."

Suggestions:

1. *Rearrange the location* of the object so that the article desired is in a location that does not require such preparatory action (change in layout), or
2. *Rearrange the position* of the object so that the article desired is in a position that does not require such preparatory action (change in position of article itself, *i.e.*, bottom side up, article on end, etc.), or
3. If such preparatory action cannot be eliminated, make the action take care of *more than one object*, or
4. Change the action of the controlling agent so that the preparatory action may be performed during the regular travel of the controlling agent.

"Hold"

"Hold" is defined as "the classification used whenever a lack of action keeps an object in a temporarily immovable (or nearly so) position."

Suggestions:

1. *Substitute a holding device* for body members so employed, or,
2. If possible, *use the between-operations carriers,* such as trucks, cradles, skids, dollies, etc., to serve as holding devices by making changes in the construction of such equipment.

"Position"

"Position" is defined as "the classification used whenever an action brings one object into an exact relationship with another object."

Suggestions:

1. *Provide a guide* of some sort to lead the one object to the desired point of placement in regard to the other object, or
2. *Make changes in the object* itself to reduce the necessity for positioning (tapered ends, etc.), or
3. Change the *location of the grasp* on the object (if object is grasped at one end and is free at other end, arc of swing of free end is much greater than if grasp is close to free end).

"Unavoidable Delay"

"Unavoidable Delay" is defined as "the classification used whenever a delay outside the control of the operator is encountered."

Suggestions:

1. *Shift some of the work* in the same operation to the idle member, or
2. *Combine* part of the previous or succeeding operation with this operation in order to utilize this delay, or
3. Consider the use of *duplicate fixtures.*

Continuing the discussion of ways and means of eliminating or greatly reducing wasted effort, we come to two motions whose improvement usually requires the development of fixtures or some type of mechanical aid. These motions are "Grasp" and "Release Load." At times this can also be said of the motions discussed in the previous section, but, because parts are not usually moved one at a time from one operation to another and because tools are not usually in the best position for immediate access, etc., these motions usually require mechanical aid for their improvement.

This mechanical aid does not mean the design and construction of automatic machinery but the use of simple fixtures, hoppers or holders. We do not advocate the use of any complicated or automatic devices because they are out of

our field, and if the wasted effort encountered does not respond to simple equipment but is of sufficient value to be worth the cost of such development, pass it on to those more qualified to do the development.

"Grasp"

"Grasp" is defined as "the classification used whenever the result of an action tends to bring an object under complete control."

Suggestions:

A. For parts:
1. *Use a hopper*, or
2. *Use a special tool* instead of a body member, or
3. *Change design of container*, or
4. *Change position of object*, or
5. If practical, grasp *more than one* object.

B. For tools:
1. *Change position* of tool, or
2. *Use a tool holder.*

"Release Load"

"Release Load" is defined as "the classification used whenever the result of an action tends to lose control of an object."

Suggestions:

A. For parts:

1. Use an *ejector*, or
2. Use a *chute*, or
3. *Change design* of container, or
4. If practical, *toss object* into container, or
5. Consider a *change in design of part* (to eliminate projections, etc.).

B. For tools:

1. Use a *suspension device*, or
2. Use a *tool holder*.

XVI

IMPROVING THE OPERATION—III

IN THIS chapter we consider first ways and means of improving a motion that can, and usually does, present considerable difficulty in the working out of improvements. This motion is "Inspect." "Inspect" will give considerable trouble, usually because the operator's mind is concentrating on the inspection and any physical movements actually performed, or set up to be performed, during the inspection must be extremely simple and require no conscious mental direction. Any attempt to set up a series of physical movements requiring any conscious mental direction during "Inspect" is almost certain to fail.

"Inspect"

"Inspect" is defined as "the classification used whenever an action results in determining pres-

ence or absence of predetermined characteristics."

Suggestions:

1. *Centralize* the "Inspect" in order to reduce the number of separate mental impressions, or
2. Perform the "Inspect" in *combination* with a series of simple physical movements, or,
3. In cases where no considerable degree of judgment is required, consider the *use of electric eyes*, etc., or
4. *Change the position* of the object so as to cover the greatest area possible for the detail required.

"Select"

"Select" is defined as "the classification used whenever an action results in making a choice between two or more objects in a known location."

Suggestions:

1. *Identify* tools or parts by characteristic markings or shapes, or,
2. If possible, *segregate* the different objects at point of origin, or
3. *Reduce* the number of items to choose from by combining items with common characteristics into a smaller number of interchangeable parts, or

4. Consider the possibility of *mechanical separation* of the different objects by screening, magnetic pulleys, etc.

"Search"

"Search" is defined as "the classification used whenever an action results in determining which of several possible locations contains the desired object."

Suggestions:

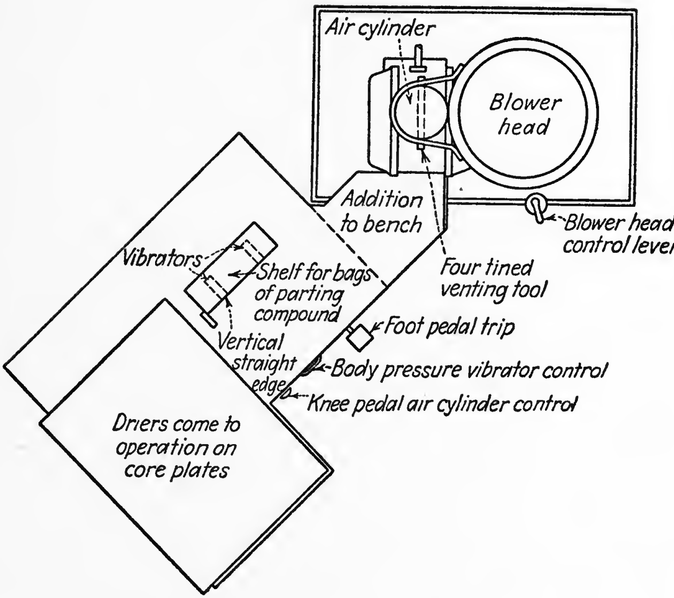
1. Assign a *definite location* to parts or tools, or
2. Provide a *definite route* for the materials or parts to follow to the operation, during the operation and from the operation.

This concludes the list of suggestions on ways and means of eliminating or greatly reducing wasteful effort. Naturally, there are many other specialized ways of managing this reduction, but, in general, the suggestions listed will aid the analyst to the greatest possible degree in the greatest number of cases.

It should be pointed out that the "Transport" motions, too, should be subjected to scrutiny in order to eliminate any excessive travels.

While it is true that the "Transport" motions have usually been among the first to undergo mechanical improvements (witness the variety of conveyors in use in the average industrial plant), do not pass over them too lightly. Be particularly watchful of those "Transport" motions which control most of the cycle time and whose movements follow a simple and repetitive path. Such cases usually lend themselves to simple mechanical improvement. To quote a common example, let us consider the development of the different means of driving screws. First, the hand screw driver; second, when the operation became repetitive enough, the ratchet-type driver; and finally, not very much faster than the ratchet type but usually less fatiguing, the power driver. This development came about because the movements were simple and repetitive, a constant rotation of the forearm clockwise and then counterclockwise, controlling a majority of the cycle time. Practically the only other factor to driving a screw by hand other than the rotation of the screw driver is the placing of the bit into the slot of the screw. Should similar, uncomplicated operations be encoun-

tered, be watchful for some simple mechanical improvement to eliminate the repetitive movements.



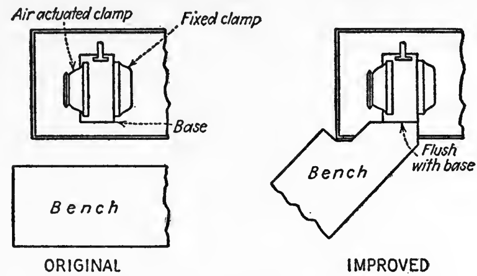
Revised layout of core-blowing operation.

XVII

IMPROVING THE OPERATION—IV

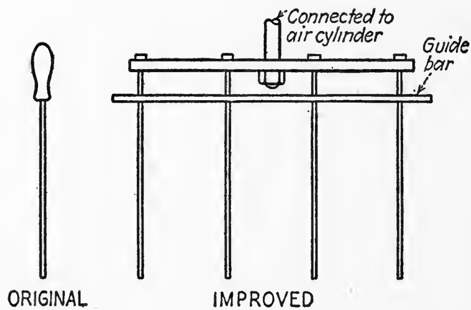
Now that we have concluded the general discussion on Improving the Operation, let us return to the core-blowing operation we analyzed and timed in its original form. This original analysis was discussed in the chapter entitled Timing the Operation —II. Let us now take each successive "Work" and "Delay" element in this operation and apply the improvement suggestions just discussed.

Element	Ineffective Work	Contributing Cause	Disposition
Get loaded core box	Sliding the box out of the clamp jaws (excessive grasp)	Low clearance of clamp jaws that hold the box during the blow	No change—sideways movement of jaws restricted because of construction of machine
Place box on bench	180-deg. turn (excessive transport)	Location of bench	Turn eliminated by placing bench in better location (See illustration on p. 90)

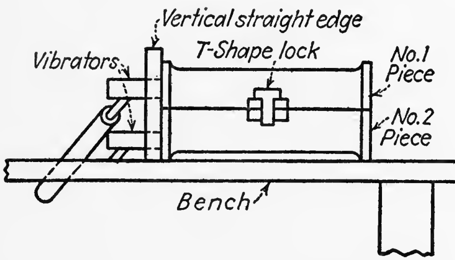


Element	Ineffective Work	Contributing Cause	Disposition
Get vent tool	None	None	See below
Place tool at core 1 and vent core	Positioning end of venting tool to opening in core box	Method of holding and using tool	Fixed relationship set up between tool and core box to eliminate positioning
Place tool at cores 2, 3 and 4 and vent cores 2, 3 and 4 (in succession)	Same as above	Same as above	As this element is repeated 4 times in succession, a four-tined venting tool operated once is thought of. Then further elimination of the pick up and lay aside of the tool and the movement of tool to box calls for a constantly positioned (yet movable up and down) four-tined venting tool in conjunction with a locating fixture for the box
Place venting tool aside	None—by itself	None	

Element	Ineffective Work	Contributing Cause	Disposition
Wait during venting	All	Nothing else for hand to do	Some work must be given to this hand or the need for the wait eliminated. As the only work possible to give this hand is rapping the box and as this should be done when the box is in a horizontal position, rapping while venting does not appear practical. However, if the new four-tined venting tool is mounted to the blower head and moved up and down by air after the box has been blown and the blower head has cleared, the fixture mentioned above can be dispensed with, as the clamp jaws will act as locators for the box. By connecting the air line of the venting tool to a knee-pedal valve, the venting can be overlapped by some other element
Get box by lock flanges	None	None	No change
Place box flat on bench	None	None	No change



Element	Ineffective Work	Contributing Cause	Disposition
Get mallet	None	None	No change
Rap box	None	None	No change
Place mallet aside	None	None	No change
Hold box during rapping	All	The need to keep box from bounding around when hit	The first thought was to provide a spring clamp to hold the box and use two mallets to rap with. The second thought, and the one adopted, was to use two vibrators (small fast-acting air hammers) set in the face of a vertical guide so that the box would be vibrated as it was drawn



Element	Ineffective Work	Contributing Cause	Disposition
Unlock box	None	None	No change
Get box at pivot point of lock	None	None	No change
Draw No. 1 piece of core box	None	None	No change in draw itself. Vibrated during draw instead of rapped ahead of draw
Place No. 1 piece on bench, inner side up	None	None	No change
Get drier from pile	None	None	No change
Wait during "Get drier"	All	Nothing for hand to do	No change—no work available

Element	Ineffective Work	Contributing Cause	Disposition
Subsequent elements down to and including "Place drier on carrying plate" excepting "Draw No. 2 piece," which will utilize the same vertical guide plate as the No. 1 piece	None	None	No change in operation except location of driers, which in order to save space are now brought to the operation on the core plates (where they have been placed by the core cleaners) instead of being supplied separately
"Get bag of parting compound" to and including "Place bag aside"	None	None	No change
Wait while box is dusted	All	Lack of work	Provide second bag of parting and dust box pieces with both hands
Subsequent elements from "Get No. 1 piece of core box" to and including "Get box by overhang"	None	None	No change
Place box in core blower	180-deg. turn (excessive transport)	Location of bench	Place bench in better location
Operate blower-head control handle	None	None	It would be possible to change to a foot-lever control, but gain is not worth the cost—no change
Wait during operation of blower-head control	All	Nothing for hand to do	See above for reason for no change

Element	Ineffective Work	Contributing Cause	Disposition
Wait for blower head to move to blowing position	All	Nothing else to do	Overlap blowing cycle with other essential work by providing a second core box to work on during blow of first box
Operate foot pedal and wait for blowing period	All	Nothing else to do	See above
Wait for head to clear box	All	Nothing else to do	See above

These changes result in the lineup of elements shown on page 95, with the symbols of the original study shown where no change was made.

We now have a total of .031 min. of delay out of a potential of .648 min. (2 × .342), or 4.8 per cent and have succeeded in reducing the elapsed time per core box from .598 min. to .342 min., or to 57 per cent, of the original time. The improvement came about because of the emphasis placed on the ineffective effort by the original analysis of the operation and the utilization of various adaptations of the general improvement suggestions. This does not mean that anyone else could not have done the same thing without the

Extension	Element times	Left	Right	Element times	Extension
	.014	Get box 1 from jaws (*A*) (slide)	Delay	.014	
.024	.010	Place box 1 on bench (slide)	Place box 2 in jaws (slide)	.010	.024
.029	.005	Get box by top overhang	Operate blower-head control	.005	.029
.059	.030	Place box flat on bench (*G*)		.030	.059
.074	.015	Get and open lock (*J*)	Get and open lock (*J*) (step on blow pedal)	.015	.074
.129	.055	Vibrate No. 1 piece, draw and place aside (*K*)		.055	.129
.141	.012	Get drier (*L*)	Delay	.012	.141
.173	.032	Place drier on cores (*M*)		.032	.173
.190	.017	Get box and drier ends and rotate 180 deg. (*N*)		.017	.190
.245	.055	(*P*) Get lock projection; Draw No. 2 piece and place aside	Get lock projection (*P*)	.055	.245
.270	.025	Get drier with cores and place on carrying plate (*Q*)		.025	.270
.292	.022	Get bag of parting; Place at No. 1 piece and dust (operate knee-pedal vent control); Replace bag	Get bag of parting; Place at No. 2 piece and dust; Replace bag	.022	.292
.310	.018	Get No. 1 piece of box and place on No. 2 piece (*S*)		.018	.310
.330	.020	Get lock and lock box (*T*)	Get lock and lock box (*T*)	.020	.330
.342	.012	Get box and place upright on bench		.012	.342

analysis but that a logical method of analysis and improvement will always show up many points of potential savings that too often are passed up by the ordinary methods of study.

The following Analysis of Operation shows the final form of our study of the revised operation.

ANALYSIS OF OPERATION

Dept. . Coremaking . . ..1..Sheet of..2..
Supervisor . . J. Brown Title. . Blow Core Box and Draw Cores Date..5/12/42...
Operator. . . . R. Leach (Improved Method) Elapsed Time.342
Observer. . . . E. Stowe Product. . . . No. 424 Cylinder. . . . . . .

Extension	Element times	Left	Right	Element times	Extension
	.014	Get box 1 from clamp jaws (slide out to bench extension)	Wait	.014	
.024	.010	Place box 1 at draw fixture (slide)	Place box 2 in clamp jaws (slide along bench extension)	.010	.024
.059	.035	Get box by top overhang; Place box flat on bench	Operate blower-head control; Place box flat on bench	.035	.059
.074	.015	Unlock left lock	Unlock right lock (step on blow pedal)	.015	.074
.129	.055	Draw No. 1 piece of core box (vibrate); Place No. 1 piece of bench, inner side up	Draw No. 1 piece of core box (vibrate); Place No. 1 piece of bench, inner side up	.055	.129
.141	.012	Get drier from core plate (by end)	Wait	.012	.141
.173	.032	Place drier above exposed cores; Place drier on cores	Get free end of drier; Place drier on cores	.032	.173
.190	.017	Get adjoining left ends of drier and box; Place box on bench, drier down (rotate 180 deg.)	Get adjoining right ends of drier and box; Place box on bench, drier down (rotate 180 deg.)	.017	.190
.245	.055	Get left lock projection; Draw No. 2 piece of core box; Place No. 2 piece on bench, inner side up	Get right lock projection; Draw No. 2 piece of core box; Place No. 2 piece on bench, inner side up	.055	.245
.270	.025	Get loaded drier; Place drier on core plate	Get loaded drier; Place drier on core plate	.025	.270
.292	.022	Get bag of parting from shelf; Place at No. 1 piece and dust (operate knee-pedal vent control); Place bag on shelf	Get bag of parting from shelf; Place at No. 2 piece and dust; Place bag on shelf	.022	.292

ANALYSIS OF OPERATION

Dept. . Coremaking. . ..2. . Sheet of. .2. .
Supervisor. . J. Brown Title. . Blow Core Box and Draw Cores Date. .5/12/42. . .
Operator. . . R. Leach (Improved Method) Elapsed Time .342
Observer. . . E. Stowe Product. . . . No. 424 Cylinder. . . . . . .

Extension	Element times	Left	Right	Element times	Extension
.310	.018	Get No. 1 piece of core box; Place No. 1 piece on No. 2 piece (rotate No. 1 piece 180 deg.)	Get No. 1 piece of core box; Place No. 1 piece on No. 2 piece (rotate No. 1 piece 180 deg.)	.018	.310
.330	.020	Lock left side of box	Lock right side of box	.020	.330
.342	.012	Get box by top overhang; Place box upright on bench	Get box by top overhang; Place box upright on bench	.012	.342

XVIII

TRAINING THE OPERATOR IN THE NEW METHODS

The crucial point of any proposed improvement is the training of the operators in the new methods. Regardless of how confident we may be of the results of a proposed improvement, the training of the first operator in the new method is always a period of trial and tribulation, especially if the operator worked either on the former operation or close to it. Regardless of the nature or degree of change, the operator's attitude is usually negative, based on one or the other of the following reasons or both:

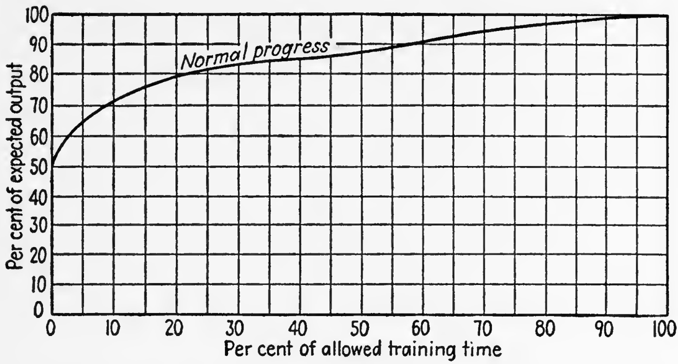
1. More work required for the same money (in his mind, output is synonymous with work).
2. Loss in incentive earnings due to having to slow down while acquiring new skills.

Of the two reasons the first is more highly stressed, but the second is usually the real reason for employee opposition.

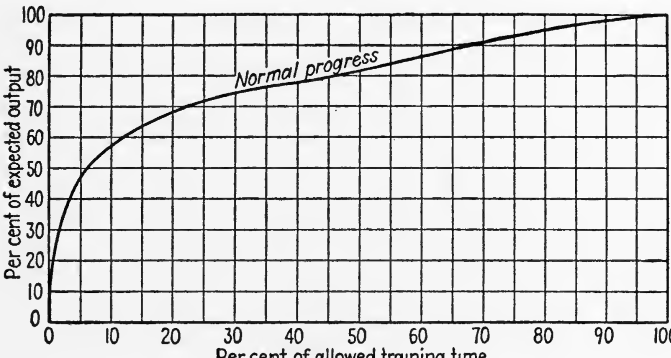
In order to overcome this latter objection, it is

recommended that training allowances, graduating in amount according to the position of the operator in the training cycle, be allowed to the operator in excess of any earnings from his production on the new or improved operation. These allowances are based on universal training curves (see charts on page 100) that have been developed through experience with such allowances. The length of training allowed to the operator is based solely upon past experience and judgment. Care must be taken that too short a training period is not allowed, thus defeating the purpose of the allowances, which is to approximate former earnings and to encourage the operator to learn the new operations as quickly as possible. (The lengths of training allowed will usually increase as the dexterity required and the number of variable elements in the new operation increase.)

For instance, if on a complete change in methods the length of training is decided upon as 10 units of 40 hr. each, the operator is allowed successively the difference between the average per cent of expected output for each of the 10 units and 100 per cent. In this case the allowed



Normal training progress. Ten to forty-five per cent changes in method.



Normal training progress. Fifty to one-hundred per cent changes in method.

difference for the first unit is 52 per cent (see chart on page 100). This difference is determined by subtracting the expected output at the 5 per cent mark (or 48 per cent) from 100 per cent (5 per cent is mid-point of first unit). Expected output as the term is used here means the output of a selected and fully trained operator working under incentive.

In the same example the operator will be allowed the difference between the average expected output for the second unit (65 per cent) and 100 per cent as soon as the first 40 hr. of training are completed, and so on for each successive unit of training.

If the operator exceeds the expected output at any point in the training period, he receives more than 100 per cent, as the training allowances are constant for specific training units. The operators are thereby encouraged to keep their output at the highest possible level during the training period and at the same time are protected against heavy loss in earnings should their output fall below the expected level.

These training allowances have also been successfully used for payment of operators who,

because of seasonal demand, etc., have been transferred to other operations in which they have had no experience. The incentive that is provided by the training allowances, to learn the new operation quickly, has cut the former training times so decisively that the extra cost of the allowances has been amply justified.

There are two schools of thought as to the best methods of training. One believes that the best results are obtained by thoroughly learning one section of the operation at a time and then progressing to the next section, going back to the first often enough to keep it from getting stale. The other believes that best results are secured from learning the entire operation at one time, thus giving the operator an opportunity to observe the effects that a right or wrong performance of one section has upon succeeding sections.

Both schools believe that visual demonstration is not enough and that the right way to train operators is to teach the correct movements along with the correct synchronization of those movements. Of course, this requires specially trained and qualified instructors, but experience

has shown that this type of instruction is well worth the extra expense, from the viewpoint of both shortening the training period and maintaining high outputs.

There are several other factors that have considerable bearing on the successful training of the first operator. The most important is: Do not experiment in front of the operators who might have to work on the new setup. Work out the new methods completely before presenting them to the operators. They are used to a successful method, and any withdrawal of tools or equipment for corrective changes only serves to undermine their confidence in the new methods. As they are usually skeptical anyway, do not aggravate the situation.

Do not necessarily select the fastest operator on the old method as the first one to instruct in the new method. The operator who has both intelligence and a cooperative attitude is the most logical choice. There is also a certain psychological advantage if this operator has not been the fastest operator, for the improved methods may enable him to produce more than the fastest operator.

Do not constantly hover around the trainee. See that he is correctly instructed and that he understands what to do and then go away. Let the training allowances provide the incentive—not the drive that your constant presence implies. Come back and check up occasionally, straighten out any backsliding and go away again.

Once the new operation is proved in by one operator, the training of other operators on the new methods is usually a matter of routine.

The training allowances shown in tabular form on pages 106 and 107 have been taken from the charts shown on page 100 by subtracting the per cent of expected output at the mid-point of each training unit (when expressed in per cent of total training time) from 100 per cent.

For example, total allowed training time is 10 units of 40 hours each. Each training unit is therefore 10 per cent of the total allowed training time. Mid-points of the units would be 5 per cent, 15 per cent, etc.

Training-allowance Master Sheet for 50 to 100 Per Cent Changes in Method

The following allowances in the table are to be used only for operators transferred from established operations to other and dissimilar incentive operations in which the operator has had no previous training.

The individual operations to which these allowances apply and the number of training units allowed for the operation shall be designated by the standards department.

The allowances in this table are to be added to the operator's earnings from production according to the predetermined length of training and the particular training unit to which the operator has progressed.

Demonstration periods in which the operator does not produce acceptable product are not included in the above.

The operator's former average earnings shall be the average of the earnings of the last 10 weeks worked on the operation from which he was transferred.

Percentage of Operator's Former Average Earnings to be Allowed Each Training Hour (Allowance to be changed as shown below)

Total training units allowed	Successive 40-hr. units of training																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	17																
2	28	7															
3	33	17	4														
4	37	23	12	3													
5	41	25	17	8	2												
6	44	28	21	14	7	2											
7	46	30	23	17	11	5											
8	48	31	25	20	15	9	5										
9	50	33	26	22	17	12	8	4									
10	52	35	28	23	19	15	11	7	3								
11	53	36	29	24	21	17	13	9	6	3							
12	55	37	30	26	23	19	15	12	8	5	3						
13	56	39	32	27	24	20	17	14	10	7	5	2					
14	57	40	32	28	24	22	18	16	12	9	7	4	2				
15	58	41	33	29	25	23	20	17	14	11	8	6	4	2			
16	59	42	34	30	26	23	21	18	16	13	10	8	6	3	2		
17	60	43	35	30	27	24	22	20	17	15	12	10	7	5	3	2	

Training-allowance Master Sheet for 10 to 45 Per Cent Changes in Method

The following allowances are to be used only for operators who are learning new methods on established operations.

The individual operations to which these allowances apply and the number of training units allowed for the operations shall be designated by the standards department.

The allowances in the table on page 108 are to be added to the operator's earnings from production according to the predetermined length of training and the particular training unit to which the operator has progressed.

Demonstration periods in which the operator does not produce acceptable product are not included in the above.

The operator's former earnings shall be the average of the earnings of the last 10 weeks worked on the operation from which he was transferred.

Percentage of Operator's Former Average Earnings to be Allowed Each Training Hour
(Allowance to be changed as shown below)

Total training units allowed	Successive 40-hr. units of training									
	1	2	3	4	5	6	7	8	9	10
1	12									
2	19	8								
3	23	12	3							
4	26	16	9	3						
5	28	17	12	7	3					
6	30	19	14	10	6	3				
7	32	21	16	12	8	5	3			
8	33	22	17	14	11	8	5	3		
9	34	23	18	15	13	10	7	4		
10	35	24	19	16	14	11	8	5	3	

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